

## 1381.0.55.001 - Research Paper: A Review of Selected Regional Industrial Diversity Indexes, 2011

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## Summary

### Main Features

#### EXECUTIVE SUMMARY

Understanding industrial composition, or the range of industries in which people in regions work, is important for policy and decision makers involved in regional (sub-state) economic development. Various theories exist about the relationship between industrial composition and regional economic development and, in particular, whether different economic outcomes are associated with diverse or specialised industry structures. This paper presents the National Average and Entropy indexes which can be used to understand regional industrial composition, by summarising the distribution of employment across industries and demonstrates their application to regions across Australia. The paper explains how these indexes are defined and how they can be constructed from ABS data sources, as well as their potential uses and limitations. Based on National Average index scores using 2011 Census of Population and Housing data, capital city regions tended to have similar industry structures to that of Australia, as did several major urban centres outside of the capital cities. The regions least similar to Australia were those with high proportions of employment in the agriculture, forestry and fishing and mining industries. Regions with high Entropy index scores were spread throughout Australia, and included both capital city and non-capital city regions. Remote regions were least likely to have employment evenly distributed across all industries. This paper also appends further information on data sources and other options for analysis of regional industrial composition.

#### INTRODUCTION

Throughout Australia's history, the structure of the economy has changed as activity in different industries has risen and fallen, and these fluctuations have been reflected in regional (sub-state) economic growth as well.

In the early to mid-nineteenth Century agriculture was dominant. Gold exports surged in the 1850s and 1860s which also saw an expansion of banking and commerce. Expanding public work during the 1870s preceded the expansion of the manufacturing industry. Federation in 1901 facilitated a continued expansion of manufacturing with the removal of customs barriers between states, as did the requirement for war materials and equipment in response to our contributions to World War I and World War II. Throughout the twentieth Century, Australia's economic activity has shifted away from agriculture, towards manufacturing and an expansion of the services industries. The 1980s and 1990s saw a decline in the relative contribution of manufacturing, followed by greater investment in mining activity in recent decades (ABS, 2012; Connolly and Lewis, 2010).

These changes had different impacts across Australia. Just as the recent growth of the mining industry contributed to larger growth in economic activity in Western Australia (WA) and Queensland than in New South Wales (NSW) and Victoria (Connolly and Lewis, 2010), regional economies also experienced a wide range of outcomes, which partly reflects their different industrial composition (Cunningham and Davis, 2011). In fact, industrial composition has been identified as "one of the principal factors", along with the size of the region, its population growth and the skills of its residents, explaining disparities in employment growth in regions (Lawson and Dwyer, 2002, p. 13).

The diversity of regional economic outcomes has implications not only for regional policy and decision makers, but national economic growth can also be affected if negative economic shocks in regions have prolonged effects (Lawson and Dwyer, 2002). The review of Regional Development Australia Committee regional plans (ABS, 2013) noted that all regions had identified at least one threat to their economy and one

that was identified by 39 of these regions was the region's reliance on one or a few main industries and the need to diversify its economy.

This paper presents two indexes which can be used to understand regional industrial composition, or the range of industries in which people work, by summarising the distribution of employment across industries. Firstly, it examines the theories linking regional industrial diversity with economic development. It presents the National Average and Entropy indexes and demonstrates their application to regions across Australia. Data from the 2011 Census of Population and Housing are used and the regional scale chosen is the Statistical Area level 4, since labour markets were a consideration in the design of these regions (ABS, 2011). Finally, the paper identifies further options for analysis of regional industrial composition.

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## **THEORIES LINKING REGIONAL INDUSTRIAL COMPOSITION AND ECONOMIC DEVELOPMENT**

There are various theories about the relationship between industrial composition and regional economic development and, in particular, whether different economic outcomes are associated with diverse or specialised industry structures.

Specialisation, a regional development theory promoting one or a few key industries, is one approach for creating and sustaining regional economic growth (Diamond and Simon, 1990). In theory, specialisation is desirable because it allows companies in the same industries to share suppliers, customers and knowledge. This can lead to cost savings arising from the proximity of similar firms through economies of scale, a pool of specialised labour, the emergence of specialised suppliers, enhanced productivity and innovation in the region. Across Australia, some aspects of specialisation theory have been influential, with many regional development strategies based around the creation of industry clusters. The creation of a 'critical mass' of firms and co-location of competing, complementary and collaborative industries is considered a strong contributor to regional economic growth (Department of Infrastructure and Regional Development, 2013). Well known examples include Silicon Valley's high technology cluster or financial services in London, New York and Tokyo. For example in Australia, under the Regional Innovation Clusters Program announced in 2011, supported clusters include a surf and lifestyle cluster in the Surf Coast area; a biotechnology cluster in Geelong and a bio-waste cluster in Bendigo (Victorian Competition and Efficiency Commission, 2011).

An alternative theory identifies the potential disadvantages of specialisation and the benefits of industrial diversity. Exposure to economic downturns in key industries, while potentially detrimental to a specialised region, are less concerning in a region with greater industrial diversity. Thus, industrial diversity is associated with greater economic stability and regional economic growth (Beckstead and Brown, 2003). Some regions, such as the Pilbara, are actively pursuing a regional economic diversification strategy (Pilbara Development Commission, 2012), while others, particularly regions with highly localised manufacturing industries such as Geelong, have endeavoured to shift away from specialisation due to the risk associated with the reliance on one or two key industries.

A related area of regional science research which has experienced strong interest in recent years is that of agglomeration economies. The study of agglomeration aims to explain the "benefits which flow to firms from locating in areas which have a higher density of economic activity" (SGS, 2012, p.7) and is most relevant to large metropolitan regions. Numerous factors have been identified, such as the existence of economies of scale, where the organisation of factors of production results in decreasing marginal costs, and reduced transaction costs, such as the ease, speed and cost of matching people to jobs (Quigley, 1998). While some agglomeration benefits may be present in specialised regions, for example as a result of knowledge sharing in a particular industry, agglomeration benefits may be more readily realised in larger, more diverse economies, as firms take advantage of access to labour and inputs, including knowledge, from a range of industries (Lawson & Dwyer, 2002; Quigley, 1998).

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## **INDUSTRIAL DIVERSITY INDEXES: THE NATIONAL AVERAGE AND ENTROPY INDEXES**

Indexes for measuring industrial diversity began to appear around the time of the Great Depression in the 1930s. Ranging from the simplistic to the complex, the appeal of indexes lies in their ability to synthesize large amounts of information into a single, easily interpreted number.

This paper presents two indexes which can be used to compare the industrial diversity of regions at a point in time. The indexes described here were chosen because of the availability of suitable data and the relative ease of calculation.

## NATIONAL AVERAGE INDEX

The National Average index compares each region's industry structure with that of the nation. For the National Average index, smaller index numbers indicate that the regional industry structure is similar to that of Australia, while larger index numbers indicate greater divergence from the national industry structure. Comparing a region's National Average index at different points in time shows whether the region's industry structure has become more, or less, similar to Australia's industry structure, rather than providing information about absolute changes over time in the regional industry structure (see Appendix 1 for information about how to calculate this index).

When comparing the National Average index scores of regions, care must be taken as the index scores do not have a ratio scale, so a region with a score of 0.10 is not "twice as diverse" as a region with a score of 0.20.

The National Average index has been used:

- to explore the links between industrial diversity and unemployment in regions of New South Wales (Mason and Howard, 2010);
- as one of the factors explaining variation in regional employment growth across Australia (Lawson and Dwyer, 2002); and
- to examine the effects of industrial diversity and population characteristics on the variability of employment in the USA (Hammond and Thompson, 2004).

The main limitation of this index is its use of the nation as a diversity benchmark (Mack, Grubestic, and Kessler, 2007, p. 484) implying the nation has the optimal mix of industries. This assumption ignores regional differences in natural resources and factor (i.e.: labour and capital) endowments, and the varying levels of regional access to markets (Mack, Grubestic and Kessler, 2007, p. 484). This limitation can be somewhat overcome by choosing a different benchmark, such as the state, another region or a "peer group" of similar regions, as appropriate. However, the National Average index will always reflect a relative, rather than a fixed, diversity benchmark. An implication of this is that changes in the index over time may reflect structural changes in the region or the nation (Attaran and Zwick, 1987, p.19).

Another limitation is that the National Average index does not indicate whether a region's distribution of employment in an industry is higher or lower than that of the nation. Comparing the percentage shares in the region and nation is required to determine this.

## ENTROPY INDEX

The Entropy index defines diversity as the same proportion of economic activity in each industry (Siegel, Johnson and Alwang, 1995, p. 375).

If employment in a region were equally distributed among industries, the Entropy index would achieve its maximum value. On the other hand, if a region's employment was concentrated in a single industry, the value of the Entropy index would be zero, indicating a lack of industrial diversity.

Like the National Average index, the Entropy index does not have a ratio scale, so a region with a score of 2.20 is not "twice as diverse" as a region with a score of 1.10.

The Entropy index has been used to compare industrial diversity both among regions and for a particular region over time (Attaran and Zwick, 1987). It has also been used to examine the link between diversity or specialisation and regional economic growth in metropolitan areas in the USA (Malizia and Ke, 1993).

The Entropy index is regarded as more objective and consistent with the concept of diversification as the absence of concentration rather than relative to another (typically national) industry structure (Attaran and Zwick, 1987, p. 24). While the Entropy index avoids some of the limitations of the National Average index, specifically the use of a national benchmark that is not fixed, its definition of industrial diversity as equi-proportional industry shares has been criticised as unrealistic (Mack, Grubestic and Kessler, 2007, p. 484).

An advantage of the Entropy index is that it can be broken down to examine the inter-industry diversification in a region over time. This ability was used by Attaran and Zwick (1987) to show the extent and pattern of diversification between and within manufacturing and non-manufacturing sectors for the US state of Oregon.

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This section presents industrial diversity index scores for Australian regions. Indexes were created for Statistical Areas level 4 (SA4s) as defined in the Australian Statistical Geography Standard (ASGS) (ABS, 2011). Industry of employment data from the 2011 Census of Population and Housing by Australian New Zealand Standard Industry Classification (ANZSIC) 2006 at the one digit level were used to create the indexes. Census data based on place of usual residence were used to create these indexes. Therefore they reflect the diversity of industries in which residents of regions work. The design of SA4 regions is intended to closely align to a labour market and for most SA4 regions a high proportion of residents both live and work in the same region (ABS, 2011). However, this is not always the case, so interpretation of index scores based on usual residence for SA4s also requires labour market analysis. Refer to Appendix 2 – Further information on data sources for further discussion of the use of place of work data.

As the two indexes measure industry structure using different methods and concepts, the National Average and Entropy index values cannot be compared. A region with an industry structure similar to that of Australia (that is, with a low National Average index score), may not be diverse on an equi-proportional basis (that is, according to the Entropy index).

Over time, the effect of changes in the population and the labour force of a region may lead to a smaller index score, implying a region is becoming more like Australia (National Average index) or more evenly spread (Entropy index) in its industrial composition. However, this may not translate to decreased vulnerability or increased economic resilience. It may, for example, be the result of a reduction in employment in a previously dominant industry. Thus, analysis of the relationships between industrial diversity and regional stability should be supported by a range of other economic information, such as population data, employment, unemployment and labour force participation rates and labour mobility.

The connections between industries and between regions should also be considered. Although a region may have an index score, indicating high regional industrial diversity, it may still be vulnerable to economic shocks due to the connections between employment in different industries. For example, employment in a region may be spread across agriculture, manufacturing and professional services, but if the manufacturing (e.g.: food processing) and professional services (e.g.: accountancy, legal services) depend on the success of another industry, in this case, agriculture, then despite the index score, the region may still be vulnerable.

Finally, although the National Average and Entropy indexes summarise information about changes in the distribution of economic activity (such as employment), into a single indicator, they do not make use of all the information available and, for example, provide no information about changes within industries or changes in the level of economic activity or employment.

#### **DATA USED FOR THIS ANALYSIS**

Data in this article were drawn from the Census of Population and Housing, conducted in August 2011. The Census provides a snapshot of employment by industry in Australia on Census Night. For more information, see ABS Census Dictionary (cat. no. 2901.0).

Industry of employment was defined according to the Australian and New Zealand Standard Industrial Classification (ANZSIC), 2006, Revision 1. Industry analysis in this paper was conducted at the one-digit level, at which there are 19 industry divisions.

Each industry's share of regional employment was based on employed residents aged 15 years or older who stated their industry of employment. Across Australia, approximately 5.6% of people aged 15 and over did not state whether they were employed and approximately 2.3% of employed people did not state their industry of employment.

The regional scale used is the Statistical Area Level 4 (SA4), as defined in the Australian Statistical Geography Standard (ASGS), 2011. SA4s are used as they approximate labour market regions or groups of labour market regions. For more information, see Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas, July 2011 (cat. no. 1270.0.55.001). Migratory - Offshore – Shipping and No Usual Address categories were excluded from the analysis. For the National Average index, Other Territories data was included in the Australian total.

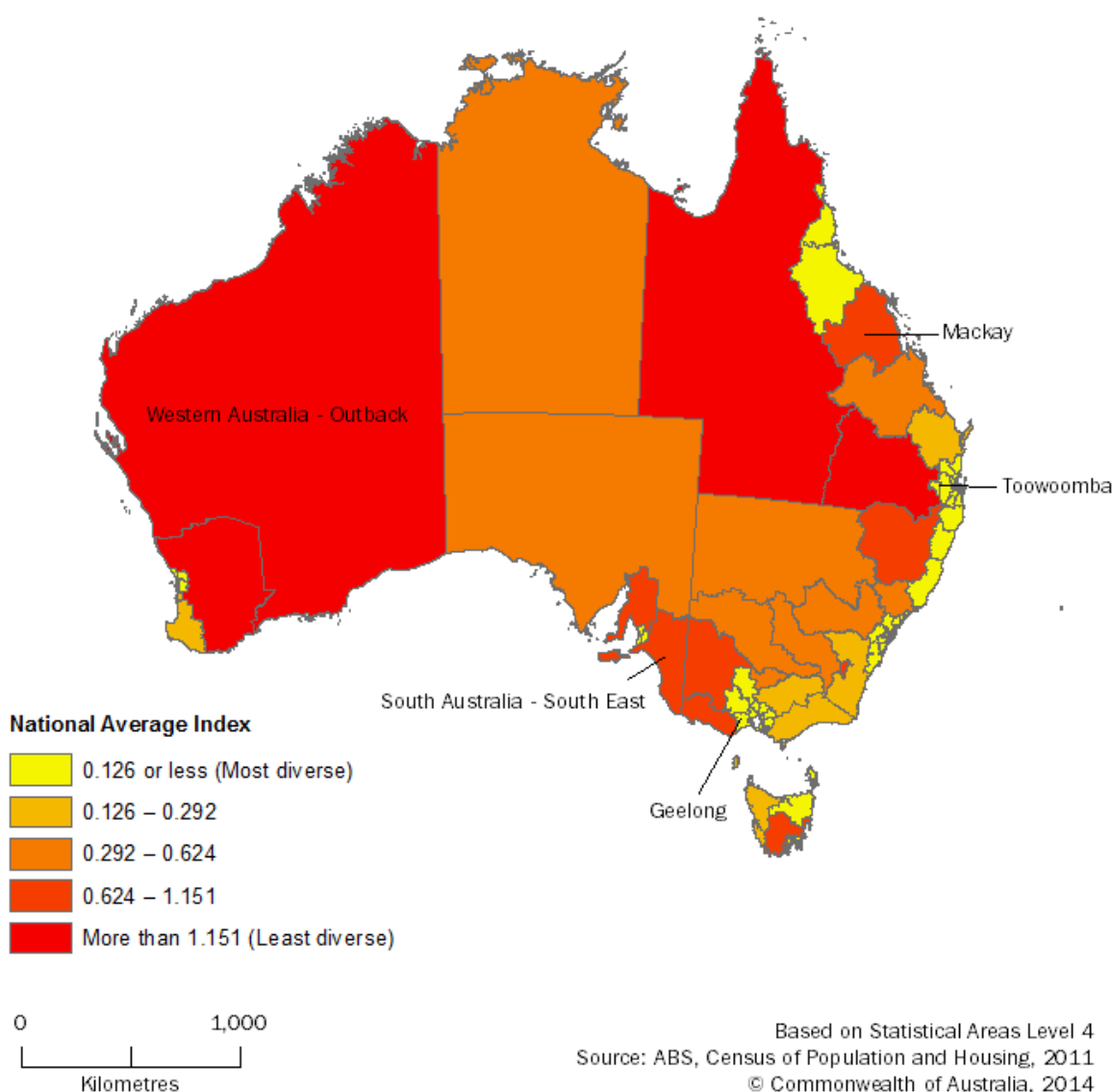
The median is the value that divides a set of data exactly in half. It is the middle value when the values in a set of data are arranged in order.

## NATIONAL AVERAGE INDEX IN AUSTRALIA

Across Australia in 2011, the health care and social assistance industry was the largest employer with 11.9% of employed people working in this industry, followed by retail trade (10.8%) and manufacturing (9.2%). These were followed by construction (8.4%), education and training (8.2%), professional, scientific and technical services (7.4%), public administration and safety (7.0%) and accommodation and food services (6.6%). The electricity, gas, water and waste services industry had the smallest proportion of employed people with 1.2%. Mining, arts and recreation services, rental, hiring and real estate services, and information media and telecommunications each employed less than 2% of workers.

Of the SA4 regions in Australia, Moreton Bay – South in Greater Brisbane, Queensland had the most similar industry structure to Australia, with an index score of 0.037. The Western Australia - Outback had the most different industry structure, with a score of 2.037. The median index score of all regions was 0.119.

**Map 1. NATIONAL AVERAGE INDEX, 2011**



National Average index scores vary considerably. Capital city regions, such as Moreton Bay – South (Qld.), Adelaide – West (SA) and Brisbane – South (Qld.), tend to have similar industry structures to that of Australia, as do several major urban centres outside of the capital cities, such as Toowoomba (Qld.), Geelong (Vic.) and Illawarra (NSW).

**TABLE 1. REGIONS WITH LOWEST AND HIGHEST NATIONAL AVERAGE INDEX SCORES, 2011**

Statistical Areas Level 4(a)	Index
TOP 10 - MOST DIVERSE	
Moreton Bay - South (Qld)	0.037
Adelaide - West (SA)	0.038
Toowoomba (Qld.)	0.040
Brisbane - South (Qld.)	0.041
Brisbane - East (Qld.)	0.042
Adelaide - South (SA)	0.043
Geelong (Vic.)	0.044
Central Coast (NSW)	0.044
Melbourne - North East (Vic.)	0.044
Illawarra (NSW)	0.046
BOTTOM 10 - LEAST DIVERSE	
Western Australia - Outback (WA)	2.037
Queensland - Outback (Qld.)	1.497
Western Australia - Wheat Belt (WA)	1.415
Darling Downs - Maranoa (Qld.)	1.406
Australian Capital Territory	1.151
Mackay (Qld.)	1.069
North West (Vic.)	0.890
South Australia - South East (SA)	0.848
South East (Tas.)	0.749
Warranambool and South West (Vic.)	0.728

(a) Statistical Areas Level 4 are defined in the ASGS (ABS, 2011)

Source: ABS, Census of Population and Housing, 2011

The region least similar to Australia was: Western Australia - Outback (2.037), with a high proportion of employment in the mining industry. Queensland – Outback (1.497) also had a high proportion of employment in the mining industry, while the Wheat Belt (1.415), in South Eastern WA and Darling Downs – Maranoa (1.406) in southern Queensland, showed high proportions of employment in the agriculture, forestry and fishing industry. Together, the agriculture, forestry and fishing and mining industries accounted for about one in four employed people in these regions. The Australian Capital Territory (1.151) had a high proportion of employment in public administration and safety, with one in three workers employed in this industry.

### Geelong, Victoria

Geelong is among the ten regions most similar to Australia, with a National Average index value of 0.044. Encompassing the city of Geelong, the surrounding coastal area to Lorne and extending inland towards Ballarat, this region has a workforce of over 110,000 people and is a major commercial and industrial centre in Victoria's south-west. In 2011, health care and social assistance, one of Geelong's growing industries, was the largest industry with over 15,000 (13.6%) people employed, followed by almost 14,000 (12.5%) people employed in retail. The manufacturing industry, the third largest industry in Geelong in 2011, accounted for almost 12,500 (11.1%) employed people, a fall of 5.4 percentage points since 2001 when it accounted for 16.5% of employed people. This is indicative of Geelong's shift from a manufacturing based economy and the region's diminishing reliance on this sector.

In 2011, Geelong's employment to labour force ratio of 94.7% was similar to those of Victoria (94.6%) and Australia (94.4%). Employees' occupations were also similar and almost 20% of employed people in Geelong were professionals in 2011, followed by 16.3% as technicians and trades workers and 12.6% as clerical and administrative workers. For Australia, the proportions were 21.3%, 14.2% and 14.7% respectively.

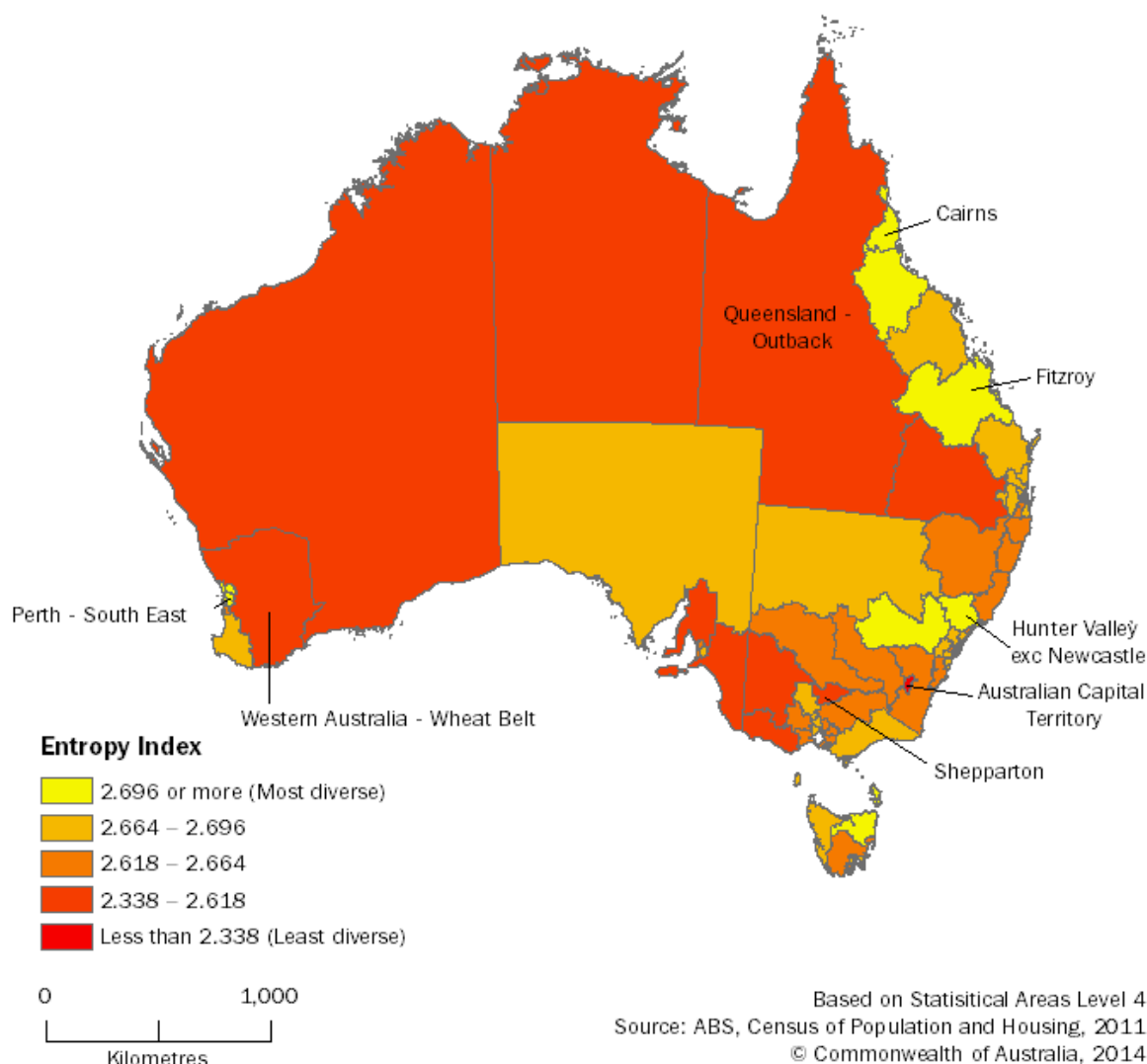
To a large degree, the industries that Geelong's residents work in reflect the industries in which jobs are available in Geelong, as a majority (76.3%) of Geelong's employed residents also worked in the region. However, over 12% stated their place of work was located in Greater Melbourne, while a further 4.3% reported no fixed address for their place of work.

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## ENTROPY INDEX IN AUSTRALIA

Entropy index scores indicate that employment was most evenly spread across industries in Perth – South East (2.739 out of a maximum of 2.944) and least evenly spread in the ACT (2.315). The median index score for all regions was 2.668.

**Map 2. ENTROPY INDEX, Australia, 2011**



Regions with high Entropy index scores were spread throughout Australia. Rural and remote regions were least likely to have employment evenly distributed across all industries.

**Table 2. REGIONS WITH HIGHEST AND LOWEST ENTROPY INDEX SCORES, 2011**

Statistical Areas Level 4(a)	Index(b)
TOP 10 - MOST DIVERSE	
Perth - South East (WA)	2.739
Hunter Valley exc Newcastle (NSW)	2.733
Fitzroy (Qld.)	2.732
Perth - North East (WA)	2.730
Perth - North West (WA)	2.715

Cairns (Qld.)	2.714
Launceston and North East (Tas.)	2.709
Townsville (Qld.)	2.708
Central West (NSW)	2.707
Perth - South West (WA)	2.705

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#### BOTTOM 10 - LEAST DIVERSE

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Australian Capital Territory	2.315
Northern Territory - Outback (NT)	2.588
Queensland - Outback (Qld.)	2.592
Darling Downs - Maranoa (Qld.)	2.594
Shepparton (Vic.)	2.598
Warrnambool and South West (Vic.)	2.601
South Australia - South East (SA)	2.602
Barossa - Yorke - Mid North (SA)	2.604
North West (Vic)	2.605
Western Australia - Wheat Belt (WA)	2.611

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(a) Statistical Areas Level 4 are defined in the ASGS (ABS, 2011)

(b) Maximum entropy score  $LN(19) = 2.944$

Source: ABS, Census of Population and Housing, 2011

Other regions with employment diversified across industries included Hunter Valley exc Newcastle (2.733), in NSW, and Fitzroy (2.732), in Queensland, both regions known for their agricultural, mining and tourism and associated services industries. Most regions in Greater Perth also achieved high index scores. These regions had high proportions of employment in the retail and healthcare and social assistance industries, as well as mining, manufacturing, construction and professional, scientific and technical services.

The ACT (2.315) had the least evenly distributed employment across industries, followed by Northern Territory – Outback (2.588). Both regions had a high proportion of employment in the public administration and safety industry (33.2% and 20.5%, respectively). Queensland – Outback (2.592), Darling Downs – Maranoa (2.594), also in Queensland, and Shepparton (2.598) in Victoria also had concentrations in particular industries, such as agriculture, forestry and fishing and health care and social assistance.

### Shepparton, Victoria

Shepparton, in the north east of Victoria, was the fifth most specialised region in Australia with an Entropy index score of 2.598. Known for its fruit growing and food processing facilities, Shepparton's manufacturing industry developed to take advantage of the region's primary production. Of Shepparton's employed population with a known industry of employment, over 13% were employed in each of the manufacturing and health care and social assistance industries, while 12.2% were employed in retail trade in 2011, collectively accounting for 39.4%. In contrast, collectively these three industries accounted for 31.9% of employed people in Australia. Although the manufacturing industry is the largest industry in Shepparton, its employment share has fallen by 2.3 percentage points since 2001 when it accounted for 16.2% of employed people.

The agriculture, forestry and fishing industry was the fourth largest industry in Shepparton in 2011 and accounted for just over 6,000 (11.6%) employed people, a fall of 6.4 percentage points since 2001 when it accounted for 18.0% of employed people and was the primary industry of employment for Shepparton.

Using ANZSIC Industry divisions provides a high level summary of employment in different industries. However, there can be much diversity of employment among industry subdivisions. For example, breaking down employment in the manufacturing industry in Shepparton reveals that almost 60% were employed in food, beverage and tobacco product manufacturing and the remaining 41.4% employed in the other 14 subdivisions of the manufacturing industry which included fabricated metal product manufacturing (6.3%) and machinery and equipment manufacturing (5.5%). In comparison, employment in the health care and social assistance industry was more evenly distributed across the industry's sub divisions, due to the presence of health care facilities, allied health services, aged care and other social assistance services in the region.

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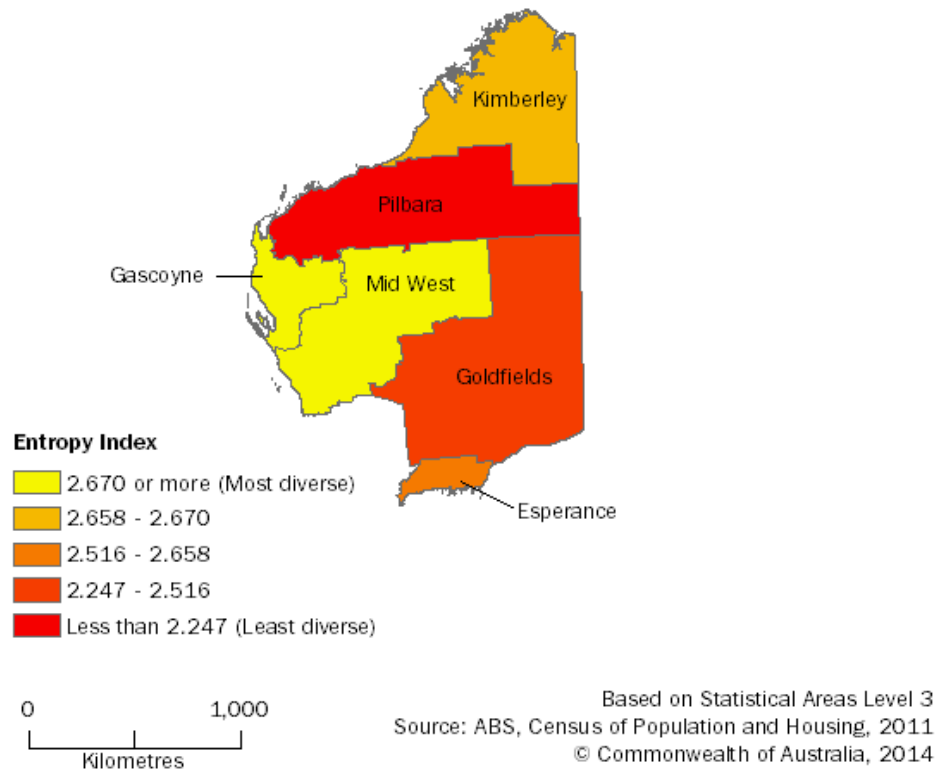
### Western Australia – Outback

As well as analysing industry structure for more detailed industry levels, the Entropy index can also be used to explore industry structure at smaller regional scales. For example, Western Australia – Outback, the largest SA4 in Australia, can be separated into six smaller regions (Statistical Areas level 3, or SA3s),



including Esperance and Goldfields in the south, Mid West and Gascoyne on the west coast and Pilbara and Kimberley in the North.

**Map 3. ENTROPY INDEX, Western Australia – Outback, 2011**



With an Entropy index score of 2.619, Western Australia – Outback is characterised by high proportions of employment in mining and construction and therefore downturns in the mining industry can have major impacts on the economies in the region. Among the SA3s in Western Australia – Outback, Pilbara had the most highly specialised industry structure, with an Entropy index score of 2.246, while the most diverse was Mid West, with 2.706. The Mid West has a diverse economy including mining, agriculture, fishing and tourism (Mid West Development Commission, 2013),

Between 2001 and 2011, the Pilbara region experienced strong growth in employment in the mining and construction industries as a result of the mining boom with an 18.2 percentage point increase in the proportion of people employed in these two industries (from 34.6% in 2001 to 52.8% in 2011). The transport, postal and warehousing and professional, scientific and technical services industries were the only other industries that also increased their employment share over this period, although not to the extent of the mining and construction industries. The increase in employment share for these industries reflects their role in supporting mining and construction. The remaining industries bore the brunt in this shift in employment share with falls in employment share ranging from 0.1 percentage points in rental, hiring and real estate services to 3.7 percentage points in retail.

Between 2001 and 2011, the Pilbara and Goldfields regions became more specialised, while the remaining regions in Western Australia – Outback diversified. This increase in specialisation in the Pilbara, where the Entropy index score fell from 2.552 in 2001 to 2.246 in 2011, supported increased economic activity in the region, and benefitted the wider Australian economy. However, lower commodity prices, lower global demand for mining outputs and a number of mines moving from the construction phase to production, (which requires a smaller workforce), are likely to impact on the economic growth of the region.

The Pilbara region is actively pursuing a regional diversification strategy (Pilbara Development

Commission, 2012) to address the issues associated with its specialised industry structure. A number of strategies are being pursued including a more diversified local economy in order to pursue more sustained economic growth and to enable the local economy to become resilient to economic downturns due to changing technology or economic conditions.

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## SUMMARY

Various indexes have been used to explore the links between growth and stability in regions and some have been described in this paper. Each index presents a different concept of regional industrial diversity and has its own merits and limitations, such as the National Average index's assumption that the national industry profile is a suitable benchmark, or the assumption of the Entropy Index, that an equal share of employment among all industries is desirable.

Using employment data from the Census of Population and Housing, National Average and Entropy index scores were created for the SA4 regions of Australia. By creating and ranking these index scores, it allowed us to compare and examine regions which were considered diverse or specialised based on their index score. The industrial composition of these regions were analysed along with other economic characteristics.

Further information about other data sources and index measures that could be used are provided in the Appendices. The choice of which index to use, and which data to use in its calculation, should reflect the researcher's objective, and, when considered in conjunction with other economic data, can inform regional industrial composition.

## APPENDIX 1 – THE NATIONAL AVERAGE AND ENTROPY INDEXES

Technically, while both the National Average and Entropy Indexes are both Entropy Indexes, the former is a National Average entropy index while the later is a log share type of Entropy Index.

### NATIONAL AVERAGE INDEX

It is calculated by taking the sum of the squared differences between the regional share of employment in each industry and the national share, divided by the national share of industry employment. It is expressed mathematically as:

For region  $j$

$$NA_j = \sum_{i=1 \text{ to } 19} \frac{(P_{ij} - M_i)^2}{M_i}$$

Where:

- $P_{ij}$  = the percentage of employment in the  $i$ th industry division, in region  $j$
- $M_i$  = national percentage of employment in industry division  $i$
- $i$  = industry division 1, 2, 3 .....19

### ENTROPY INDEX

The Entropy index for a region  $j$  is calculated as:

$$EI_j = - \sum_{i=1}^{19} x_{ij} \ln(x_{ij})$$

Where:

- $x_i$  = the industry share of 'economic activity' (in this paper, employment)
- $i$  = the industry division
- $\ln$  = the natural logarithm operator.

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## APPENDIX 2 - FURTHER INFORMATION ON DATA SOURCES

### CENSUS WORKING POPULATION DATA

The Census supports the analysis of regional industrial composition because data are available about employed people at small regional scales and for detailed breakdowns of industry classification. While Census data based on the usual resident population has been used to describe the industries in which the residents of regions work, it is also possible to use working population, or “place of work” data, to analyse the industries in which work is carried out in a region. For those that stated their industry of employment in the Census, not all respondents stated their place of work (for Australia, 1.4% are not stated and a further 3.8% stated no fixed address). Other reasons for missing data on place of work is where the work address data can only be coded to Capital city undefined or State/Territory undefined (for Australia this was 1.4% and 4.8% respectively), however this proportion varied considerably (from 0.3% to 11.8%) for individual SA4s, thus the extent of non-response should be considered before using working population data.

Regional analysis of employment is complicated by the fact that people, especially in smaller metropolitan areas, can live in one region and work in another. While industry diversity indexes can be created on either a place of work or place of usual residence basis, there are conceptual and practical differences between the two approaches. An index based on place of work provides an indication of the diversity of employment opportunities in the region, while an index based on place of usual residence provides an indication of the diversity of industries in which the residents of the region are employed. Workers in some industries, such as transport and construction, may have difficulties identifying their place of work, which can contribute to bias in a place of work based index, so attention should be paid to the proportion of not stated and no fixed address responses.

The choice of place of work versus place of usual residence data may also be influenced by the other variables a researcher wishes to analyse. Using the Census data source allows the joint analysis of other personal characteristics, such as levels of education or income earned.

## **COMPARISON OF INDEXES CREATED USING CENSUS (PLACE OF USUAL RESIDENCE), CENSUS (PLACE OF WORK) AND LABOUR FORCE SURVEY (PLACE OF USUAL RESIDENCE) DATA**

Indexes have been created for regions of Australia using:

- Census of Population and Housing - Employment by industry, based on place of work and place of usual residence, for 2011.
- Labour Force, Australia, Detailed, Quarterly, Feb 2014 (cat. no. 6291.0.55.003), data cube RQ1 - Employed persons by region (ASGS SA4), Sex and Industry (ANZSIC division).

### **National Average index**

Index scores based on employment by place of usual residence indicated greater industrial diversity than place of work data for most regions in Australia. Conceptual differences between the two Census variables of place of work and place of usual residence may have contributed to this as would the non-response bias for the place of work variable.

Comparison of the three National Average indexes reveals similar rankings for regions using Census place of usual residence and labour force data. Place of work rankings were less consistent when comparing regions with the highest levels of diversity. All three indexes were consistent in the ranking of the top ten regions with high levels of industry specialisation.

### **Entropy index**

Index scores based on place of usual residence generally indicated greater industrial diversity than place of work data. This was true for a majority of regions and is consistent with the National Average index results.

As noted in the National Average approach, this difference may be due to the conceptual difference between place of work and place of usual residence, and also to data issues associated with non-response bias in the place of work variable.

Thus the choice of variable will influence the results and their interpretation.

## **LABOUR FORCE SURVEY DATA**

Regional employment data is also available on a quarterly basis from the Australian Labour Force Survey (see Labour Force, Australia, Detailed, Quarterly (cat. no 6291.0.55.003)). This data series contains average annual employment by industry (ANZSIC division) for SA4s. The labour force survey offers timely regional employment information; however as a survey, it is subject to sampling error, so the relative standard errors should be taken into consideration.

## INCOME DATA

Calculating the industry share of earnings, rather than employment, is an alternative approach which can be used for creating National Average and Entropy indexes. Regional personal income data are available in the Census however earnings data (ie only wages and salaries) only is not available. Earnings data may in future be available from other ABS data sources such as a Linked Employer-Employee Dataset (ABS, 2014) and the Australian Taxation Office.

## BUSINESS DATA

Industry structure can also be measured according to each industry's share of businesses, or business turnover, in a region. These data are available from Counts of Australian Businesses, including Entries and Exits (cat. no. 8165.0), which provides regional estimates of the number and size (in terms of employees and business turnover) of businesses in each industry division.

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## APPENDIX 3 – FURTHER INFORMATION ABOUT OTHER INDEXES

Interest in regional economic development and the interactions between industry and employment have given rise to a number of indexes throughout regional science literature. The Portfolio Variance and Structural Change index are two of the more common.

### PORTFOLIO VARIANCE INDEX

The Portfolio Variance index provides an indication of both regional economic diversity and expected instability. It originates in the finance literature (Markowitz, 1952) in which it represents the risk (i.e.: the variability of returns) of a portfolio of financial assets. The risk of an asset portfolio depends on the risk of the individual assets and the proportion of the portfolio allocated to those assets; however, due to the relationships between asset returns, a diversified portfolio can have lower risk than the sum of the risk of the individual assets, because assets may respond differently to the same economic conditions. In regional science, the index provides a measure of the volatility of regional employment, as regions may tend to experience employment growth in some industries at the same time (such as mining and construction), or growth in some industries and decline in others (such as importing versus export exposed industries).

The Portfolio Variance index ( $\sigma^2$ ) is calculated as:

$$\sigma^2 = \sum_{j=1} w_j^2 \sigma_j^2 + \sum_{i \neq j} w_i w_j \sigma_{ij}$$

Where:

$w_i$  = the proportion of regional employment in industry  $i$

$\sigma_j^2$  = the variance of regional employment in industry  $j$

$\sigma_{ij}$  = the covariance of regional employment between industries  $i$  and  $j$

The Portfolio Variance index has been used widely in the regional sciences literature. See, for example, Conroy (1975), Wagner and Deller (1998) and Trendle (2011), who used it to analyse employment growth and change in regional Queensland.

The Portfolio Variance requires a time series of employment by industry data, to enable correlations between industries to be calculated. Like much economic data, such time series often violate the assumptions necessary for the valid identification of relationships between variables. In particular, economic time series are often non-stationary, with distributions (means and / or variances) that change over time. Econometric modelling techniques are often applied to the data before it can be used to calculate the Portfolio Variance. Consequently, this index is much more complex to create than the two presented in

this paper, and no single modelling approach can be recommended for all regional data. For more information on the Portfolio Variance Index and the various approaches to calculating it, see Hunt and Sheesley (1994).

## STRUCTURAL CHANGE INDEX

The Structural Change index provides a measure of how much a region's industry structure has changed, presenting the change in industry economic activity over a period of time. It is calculated as:

$$SCI_t = \frac{1}{2} \sum_{i=1}^n |s_{it} - s_{it-1}|$$

where  $s_{it}$  is the percentage employment share of industry  $i$  in the economy at time  $t$ .

This index was used by the Productivity Commission (2013) to analyse recent changes in the composition of the Australian, state and territory, and regional economies.

Like other indexes, the Structural Change index summarises information about changes in the distribution of economic activity (such as employment), into a single indicator. However, it does not make use of all the information available and, for example, provides no information about changes within industries or changes in the level of economic activity or employment.

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## About this Release

This paper presents two indexes which can be used to understand regional industrial composition, or the range of industries in which people work, by summarising the distribution of employment across industries. Firstly, it examines the theories linking regional industrial diversity with economic development. It presents the National Average and Entropy indexes and demonstrates their application to regions across Australia. Data from the 2011 Census of Population and Housing are used and the regional definition chosen is the Statistical Area level 4, since labour markets were a consideration in the design of these regions (Australian Statistical Geography Standard (ASGS), 2011 cat.no.1270.0.55.001). Finally, the paper identifies further

options for analysis of regional industrial composition.

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